Overview and metadata of the Food Web Dynamics Program:

Modeling consumption for use in fish stock assessments

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L. Smith

FWDP Program Review

1. Summer of 2009.
2. Overview and metadata, updated through 2012.
3. Review documentation and products available on network:

   \\net\fhdata1\fhdata2\bsmith\FWDP_Review

Program Objectives

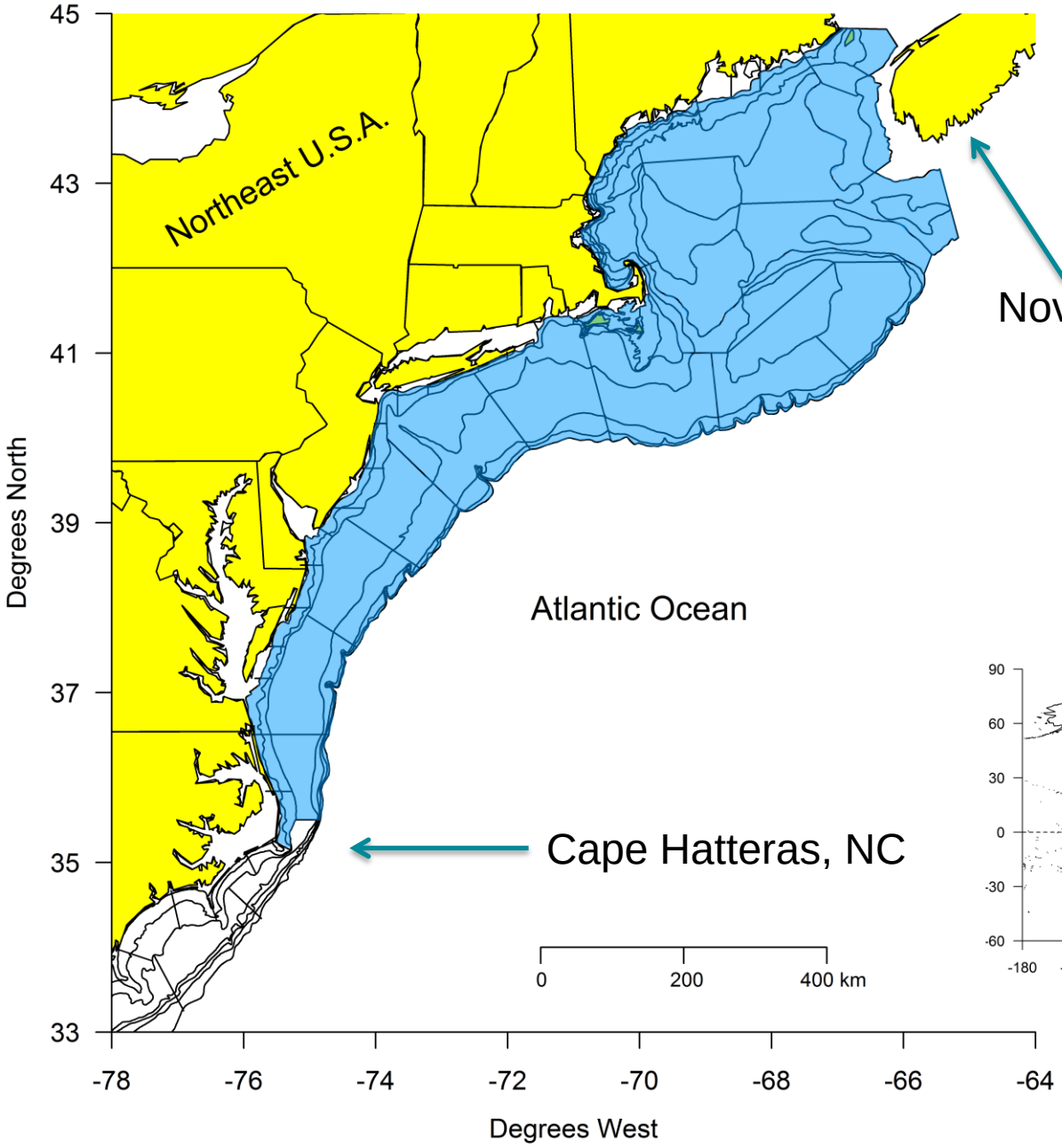
1. Quantify trophic interactions of the NE U.S. continental shelf.
2. Estimate predation mortality, and model species interactions that influence the status of commercial fish stocks.
3. Relate diet variability to changes in population- and community-level processes.

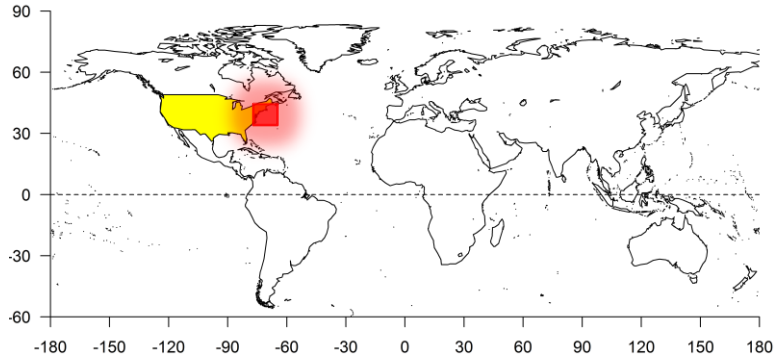
Diet Sampling

1. From 1973 to present, primarily cod, hakes, flounders.
2. From 1977 to present, expand to 195 total predators, but 31 sampled throughout time series (4000+ stomachs).

3. Two primary seasons: spring, fall, but winter & summer also available.
4. Broad geographic coverage.
   – Cape Hatteras, NC to Nova Scotia.

Northeast U.S. Continental Shelf





At-sea Biological Sampling

Length

Weight

Age & Growth

Sex & Maturity

Diet Sampling

Special Sampling

Station Complete

Time

Diet Data Collection

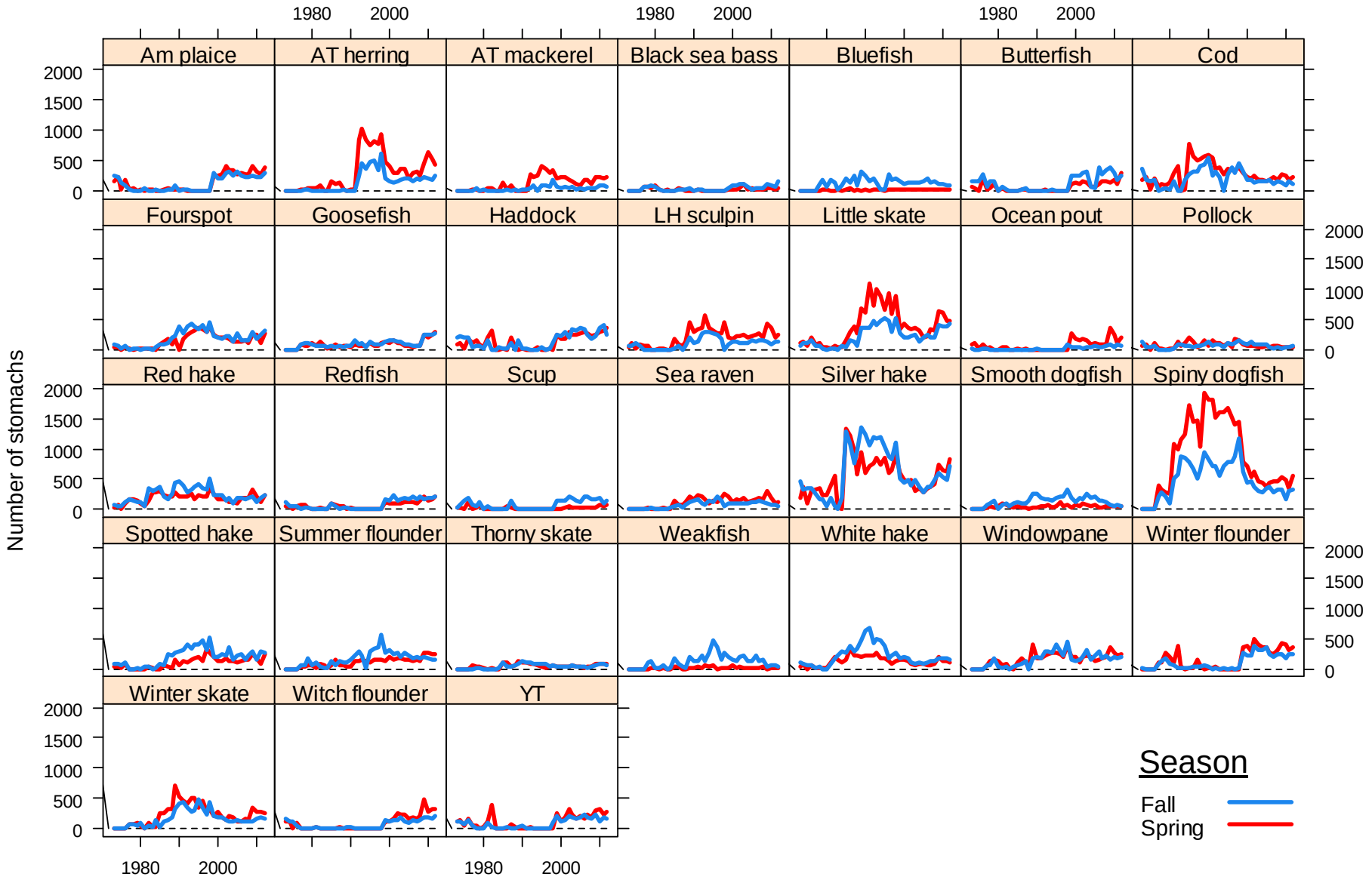
1. From a selected subset of BTS catch.
2. Stomachs eviscerated.
3. Total volume measured.
4. Prey taxa separated, % estimated.
5. Prey digestion noted (Fresh, Partial, Well).
6. Prey abundance estimated.
7. Prey lengths measured for key prey.
8. Prey comments (parasites, trawl feeding).

Diet Data Collection

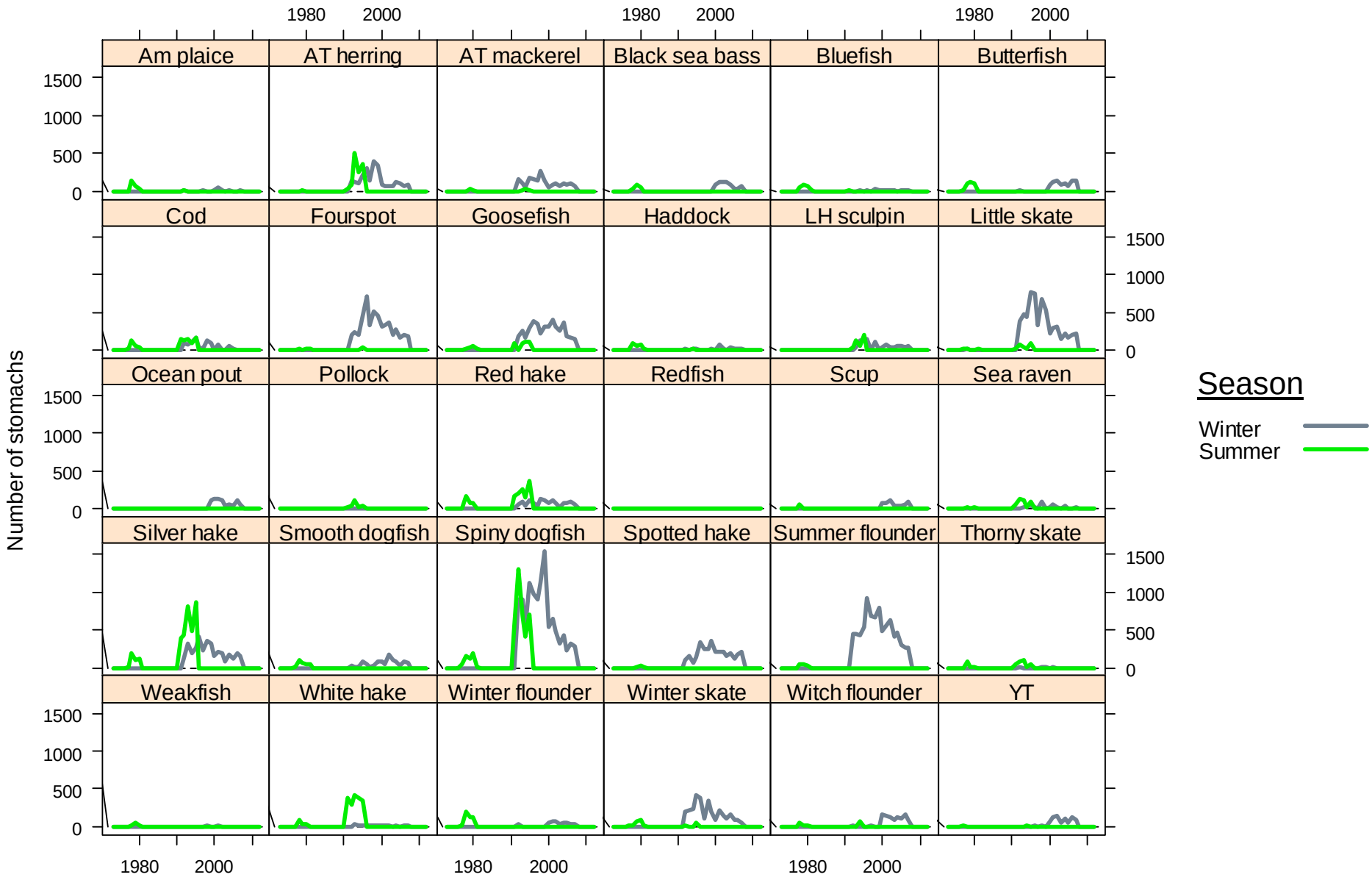
S. Pike

1. Every 25th station, 2004-2010.
2. All samples that would have been processed at sea are brought back to the lab for processing under a microscope.
3. Total weight measured (greater resolution).
4. Prey taxa separated, weight by taxa, % calculated.
5. Prey abundance and lengths measured.

Sampling by Species and Season



Sampling by Species and Season



Diet Data- Prey Taxa

1. Prey taxa are requested to be at the most resolved taxonomic level a “cutter” is comfortable reporting.
2. Advice is to choose a taxonomic level with most confidence.
3. Tradeoff of lower taxonomic resolution vs greater speed of stomach processing (and thus greater # of stomachs).

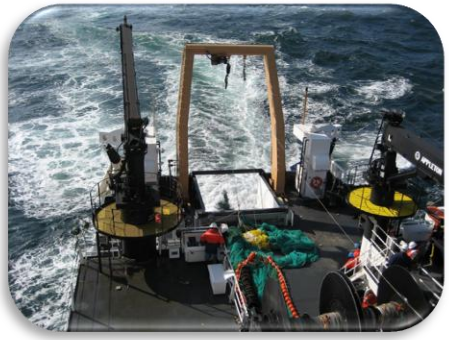
Diet Data- Prey Taxa

1. Most of our acceptable taxonomic resolution levels are reasonable even for novices; usually class or order (some family) for most inverts, genus or species for most fish.
2. Over 1,300 distinct prey taxa in database.
3. Offer 2 taxonomy/prey id workshops and ~3-4 “hands on” cutting workshops per year.

Diet Data Gaps

A. Miller

1. Summer and winter seasons for all species.
2. Inshore areas along NE coast.
3. Other geographic regions of importance (e.g. canyons, closed areas).
4. Data specific to bottom trawl survey.
5. Aim to provide a broad understanding of fish trophic ecology to address many predators and prey over entire continental shelf.

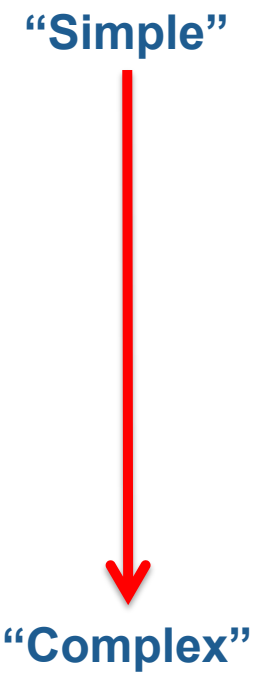


Modeling Consumption

1. Single and multispecies assessments.
2. Several approaches available.
3. Evacuation rate models.
4. Example application from identifying major predators to shelf/stock total consumption.

Approaches to Estimate Consumption

1. % BW
2. Daily ration
3. C/B (aka Q/B) ratios
4. Evacuation Rate models
5. Functional response models
6. Bioenergetics models



Evacuation Rate Models

1. Elliott & Persson (1978), Eggers (1977), modified from Bajkov (1935).
2. Requires stomach contents and temperature.
3. Models evacuation (of stomach contents) rate.
4. Assumes non-linear evacuation, constant consumption, and that consumption = what was evacuated.

Example Application

1. Major Fish Predators.
2. Numbers of Stomachs by Season and Year.
3. Major Inputs and Methods for Consumption.
4. Variance estimates.
5. Prey Lengths.
6. Predation-Catch Overlap.

Major Fish Predators

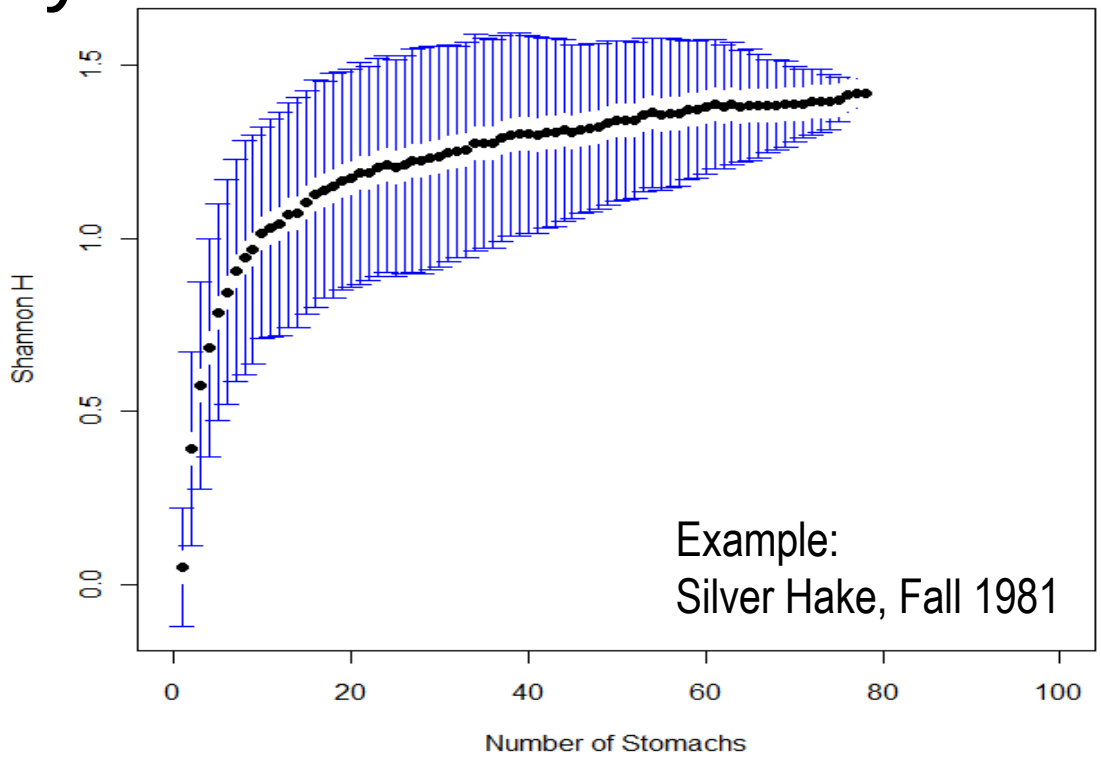
Predator	freq	total n stomachs	%freqO
BLUEFISH	300	5385	5.57
SPINY DOGFISH	184	69815	0.26
SILVER HAKE	128	53144	0.24
SUMMER FLOUNDER	105	19254	0.55
GOOSEFISH	90	12244	0.74
SMOOTH DOGFISH	49	8313	0.59
WEAKFISH	32	5481	0.58
SPOTTED HAKE	27	15197	0.18
POLLOCK	26	6232	0.42
WINTER SKATE	23	19002	0.12
FOURSPOT FLOUNDER	23	18780	0.12
BUCKLER DORY	19	469	4.05
STRIPED BASS	16	1367	1.17
ATLANTIC COD	11	21123	0.05
LITTLE SKATE	9	31472	0.03
WHITE HAKE	9	15698	0.06
BLACK SEA BASS	8	2948	0.27
SEA RAVEN	7	8623	0.08
CLEARNOSE SKATE	6	2088	0.29
ATLANTIC ANGEL SHARK	4	158	2.53
RED HAKE	3	19595	0.02
ATLANTIC MACKEREL	3	8021	0.04

Predator	freq	total n stomachs	%freqO
HADDOCK	2	12149	0.02
ATLANTIC CROAKER	2	1381	0.14
STRIPED SEAROBIN	2	719	0.28
NORTHERN SHORTFIN SQUID	2	3072	0.07
STRIPED BONITO	2	2	100.00
DUSKY SHARK	1	71	1.41
SANDBAR SHARK	1	68	1.47
SAND TIGER	1	7	14.29
BLUNTNOSE STINGRAY	1	83	1.20
BARNDOOR SKATE	1	2160	0.05
OFFSHORE HAKE	1	1204	0.08
WINDOWPANE	1	16599	0.01
SCUP	1	4769	0.02
GREATER AMBERJACK	1	9	11.11
BANDED RUDDERFISH	1	13	7.69
SHORTFIN MAKO	1	1	100.00
ATLANTIC SHARPNOSE SHARK	1	221	0.45
INSHORE LIZARDFISH	1	42	2.38
LONGFIN SQUID	1	3080	0.03
WARSAW GROUPER	1	2	50.00
COBIA	1	27	3.70
KING MACKEREL	1	17	5.88

Predators with consistent butterfish predation > 1% diet composition by mass for any 5-year block of time.

Number of Stomachs by Season and Year

1. Assessing the minimum number of stomachs per season-year.
2. Absence of prey truly zero?
3. Presence of prey?



Methods: Evacuation Rate Models

1. Evacuation rate: $E = \alpha e^{\beta T}$
2. Consumption: $C = 24\ E\ \overline{S}$
3. $\alpha = 0.002$ or 0.004; $\beta = 0.115$
4. Durbin et al. (1983) values.
5. Scaling consumption to season and predator population.

Major Data

1. Literature values for α and β.

2. Ambient temperature from bottom trawl survey.

3. Predator total stomach amount.
    - Sum of individual prey amounts, weighted by numbers of fish per tow or stratum area.

4. Predator diet composition (proportion of prey).

5. Predator abundance.

An Example Calculation

1. $E = \alpha e^{\beta T}$
2. $C = 24\ E\ \overline{S}$, (per capita, all prey)
3. $C_{\text{prey fall(spring)}} = 24*E*182.5*\text{prey}_{\text{fall(spring)}}$

4. Annual population level consumption:

   $C_{annual} = \text{Abundance}_{annual} * (C_{\text{prey fall}} + C_{\text{prey spring}})$

5. Annual total consumption:

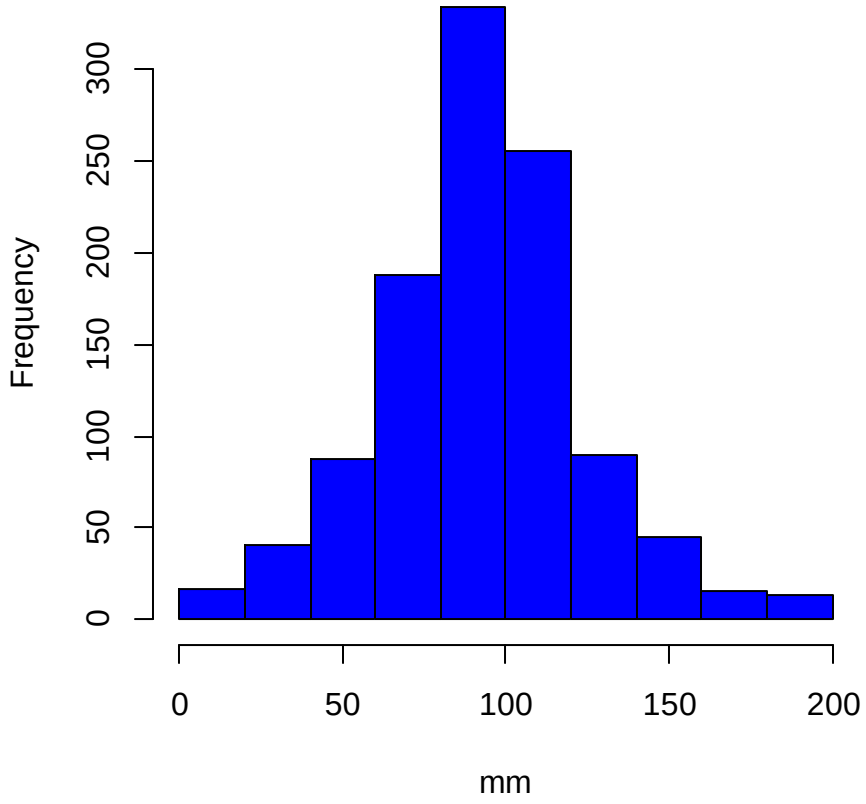
   $C_{total} = \text{Sum } C_{annual}$ across predators

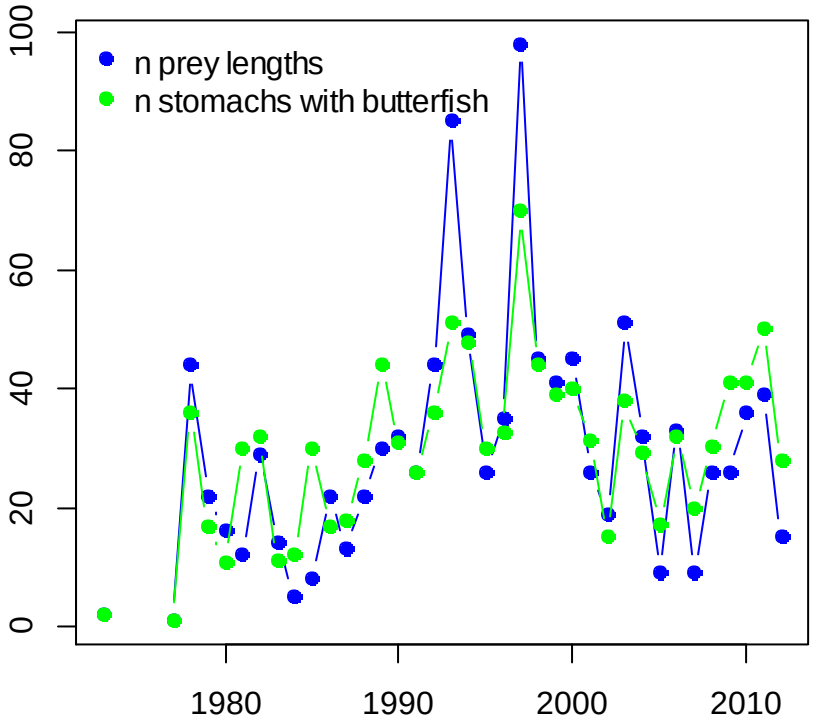
Variance Estimates


L. Smith

1. Previously left as unknown.
2. Methods in place to generate variance and CV for predator consumption and total consumption.
3. Bootstrap consumption distributions from means and standard deviations for alpha and beta (literature), temperature, diet, and predator abundance, assuming log-normal distributions.

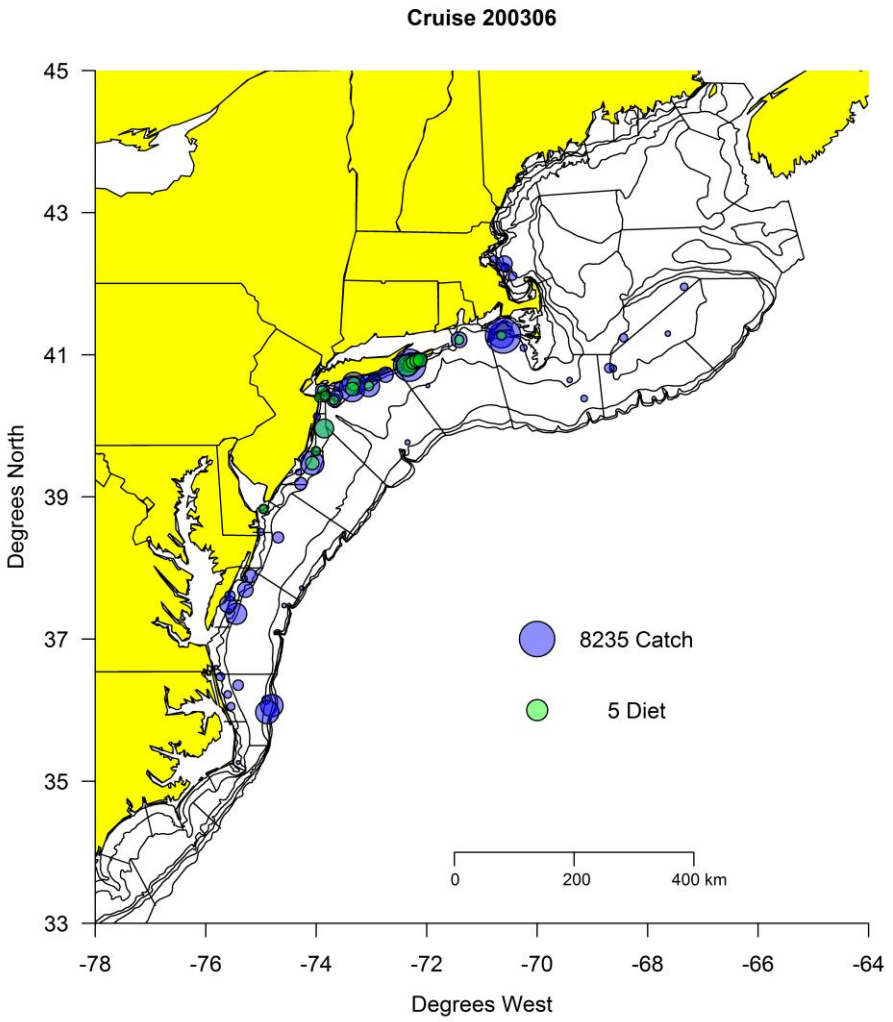
Other Useful Data: Prey Lengths

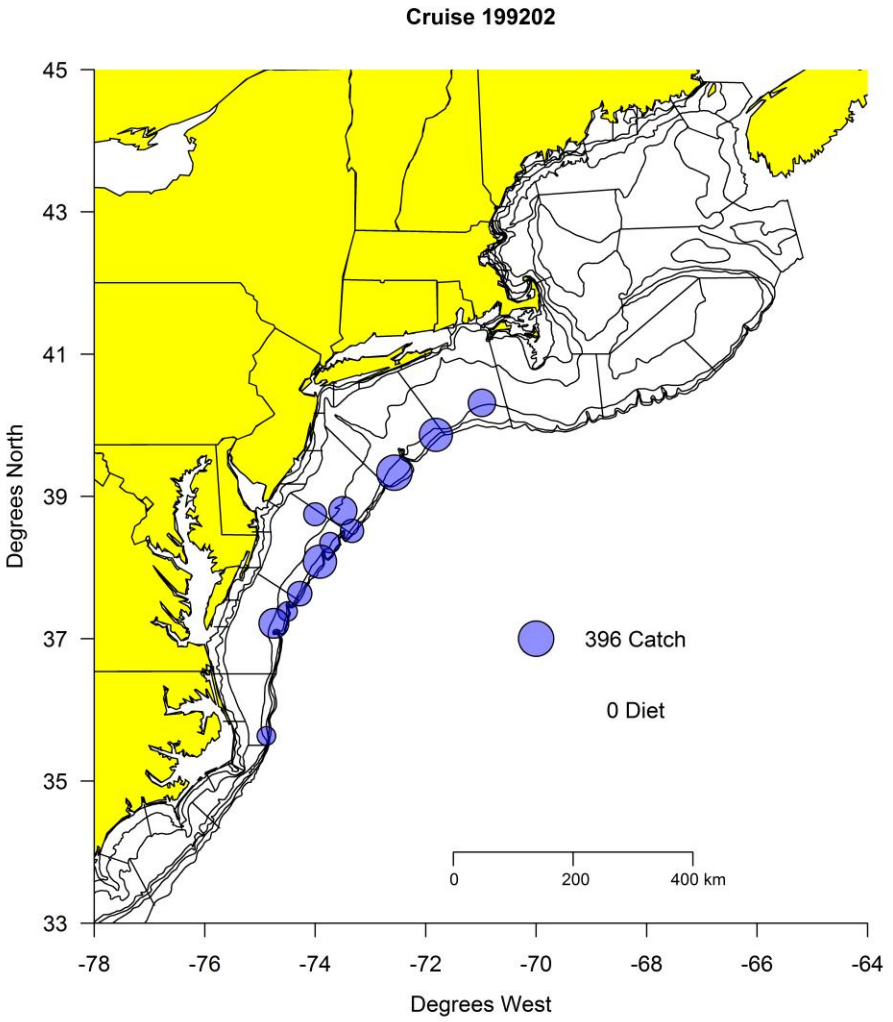




- 1087 records aggregated across predators and time

Predation-Catch Overlap





•Catches with >100 butterfish and all stomachs with butterfish displayed

D. Chevrier

Conclusions

1. A lot of diet data, but how to integrate into assessments, index to scale M, other predation indices, absolute measure of removals?
2. Exploring diet data and estimating consumption have been TORs for assessments since 2005. Routine interest of assessment scientists to evaluate these data.

A. O'brien

Thank you!

1. Program review documentation and products available on network:

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